"On the Innervation of Antagonistic Muscles. Sixth Note." By C. S. SHERRINGTON, M.A., M.D., F.R.S. Received December 30, 1899,—Read January 18, 1900.

Machine-like regularity and fatality of reaction, although characteristic of spinal reflexes, is yet not exemplified by them to such extent that similar stimuli will always elicit from the spinal animal similar responses. This want of certainty as to response is an interesting difficulty attending the study of spinal reactions. The variation in the responses of the skeletal musculature manifests itself not only in regard to the extent of the movement but also in regard to the direction of the movement.

Some of the factors determining the character of the reactions are factors contained within the stimulus. Important among these is the "*locus* of the stimulus." Thus it has long been known that the direction and other characters of the reflex movement are influenced by the mere location of the stimulus. Nevertheless stimuli identical in all respects, including locality, may evoke reflex movements of widely different, even of absolutely opposite, character. Such differences of response must be referred to differences obtaining at the time in the spinal organ itself. One cause for such differences seems indicated by the following observations :—

The most usual, indeed the almost invariable, primary reflex movement of the hind limb of the spinal dog (and cat), when spinal transection has been performed in the cervical or upper thoracic region, is flexion at hip, knee, and ankle ; the limb is "drawn up." This movement can be well obtained by, among other stimuli, the pressing of the pads of the digits upward so as to extend the toe-joints, a stimulus that in some measure imitates the effect upon those joints of the bearing of the foot upon the ground under the animal's weight. Extension as a reflex result from this stimulus is, in my experience, never met with in the homonymous limb in the early time after transection. When a certain period has elapsed, three weeks or more after transection, and shock has largely subsided, it becomes possible to, at times, obtain extension at hip as the primary movement in the homonymous limb. The pressing of the toe-pads upwards, spreading and extending the digits, elicits a sharp movement of extension at the hip, if at the time the initial posture of hip and knee be flexion. If the initial posture of hip and knee be extension, the primary reflex movement excited is, in my experience, invariably flexion. The reflex movement is, it is true, not unfrequently flexion, even when the initial posture is one of flexion ; but it is, on the other hand, very frequently, and especially preponderantly in certain individual animals, extension. The passive assumption of a flexed posture at hip and

knee seems to favour the reflex movement at those joints taking the form of extension. The influence of the posture of the ankle-joint upon the reflex movement at the hip seems negligible, for I have often remarked the reaction at the hip to be unaltered, whether the ankle were flexed or extended, at the time of excitation.

In some dogs, when the spinal transection has been made at the hinder end of the thoracic region, stimulation of the skin of the limb evokes the usual primary flexion at hip and knee wherever the *locus* of the stimulus, except it be in the upper three-fourths of the front of the thigh. Applied in this latter region the stimulus, if the limb be midway between extension and flexion, not unfrequently evokes reflex extension at hip and knee; it does not evoke extension if the initial posture of the limb be extension; but if the limb be, at the time of application of the stimulus, well flexed at hip and knee, reflex extension, instead of reflex flexion, becomes the rule.

In the spinal frog, as in the spinal dog, flexion at hip and knee is the regular reflex response of the musculature of the homonymous hind limb to skin stimuli applied at any part of the surface of that limb. This being true when the initial posture of the limb is, as when pendent, one of extension at hip, knee, and ankle, a difference becomes evident when the initial posture is one of flexion at those joints. In the latter case excitation of the skin within a small gluteal and pubic area, lateral and somewhat ventral to the cloacal orifice, causes extremely frequently not flexion at hip, but extension at that joint. Stimuli (mechanical and chemical) to that area which evoke flexion at the hip-joint when the initial posture of the limb involves extension at that joint, evoke, when the initial posture is flexion, reflex extension at the joint.

These instances seem to indicate distinctly that the direction which a spinal reflex movement elicited by stimuli similar in all respects, including "locality," may take, is in part determined by the posture already obtaining in the limb at the time of the application of the stimulus.

The reaction described above for the spinal frog holds good after previous removal of all the skin from both hind limbs, with the exception of the small gluteal piece necessary for application of the skin stimulus. It would appear, therefore, that the influence of the posture of the limb upon the spinal condition and reaction is not traceable to the nerves of the cutaneous sense-organs of the limbs. There still remain the afferent nerves subserving muscular sense, and connected with the sense-organs in muscles, tendons, and joints. These, as is well known, are largely affected by the various postures of the limb, even by such postures as are passively induced.